PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : E21B 33/10, 43/10 | A1

(11) International Publication Number: WO 99/13195

(43) International Publication Date: 18 March 1999 (18.03.99)

(21) International Application Number: PCT/IB98/01394

(22) International Filing Date: 8 September 1998 (08.09.98)

(30) Priority Data:
08/925,971 9 September 1997 (09.09.97) US
09/148,667 4 September 1998 (04.09.98) US

(71)(72) Applicant and Inventor: NOBILEAU, Philippe [FR/FR]; 40, chemin du Vinaigrier, F-06300 Nice (FR).

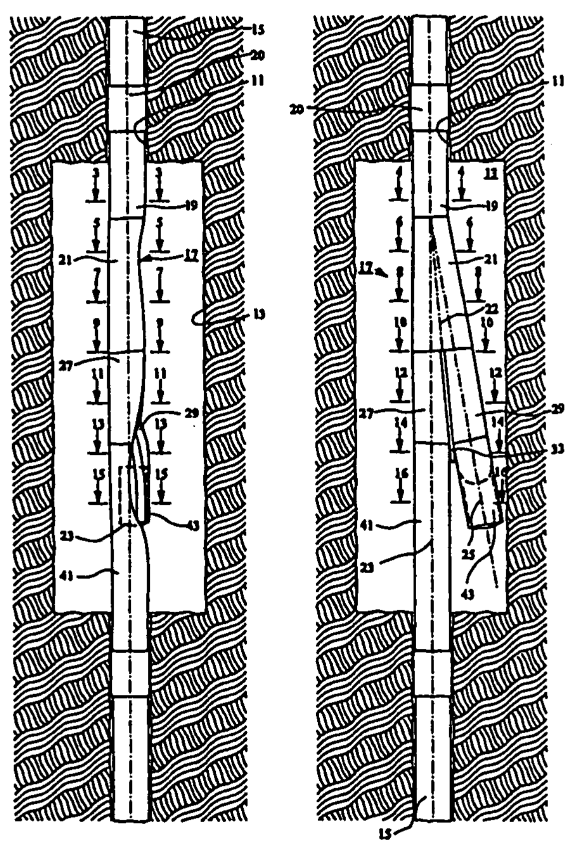
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: APPARATUS AND METHOD FOR INSTALLING A BRANCH JUNCTION FROM A MAIN WELL

(57) Abstract

A casing junction member connects in a well between a main casing and a lateral branch casing. The junction member has an upper end section which connects to the main casing extending above the member. It has a lower end section that is coaxial and connects into the main casing below the junction member. The junction member has a lateral section which extends downward for connecting to lateral branch casing. The junction between the main section and the lateral section has enlarged sections that are formed by opposed cones. A removable or drillable closure member blocks the lateral passage while in the collapsed and expanded positions. The casing junction uses internal fluid pressure to move from collapsed position to expanded position.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

APPARATUS AND METHOD FOR INSTALLING A BRANCH JUNCTION FROM A MAIN WELL

Technical Field

This invention relates in general to the construction of a lateral branch for a primary well and particularly to a junction member which sealingly connects the main borehole casing and the branch liner casing.

Background Art

In recent years, well construction technology has yielded substantial increases in well productivity with the spread of horizontal drilling for the bottom end section of the well. Unfortunately horizontal drilled wells provide limited zonal isolation and do not always permit good completion practices regarding the independent production of different production zones. Research efforts are now concentrating on the possibility of drilling lateral branches either inclined or horizontal from a primary well to enhance further reservoir productivity. Also lateral branches open the potential of tapping several smaller size reservoirs spread around from one single well without the need to sidetrack and redrill the well when moving the production from one production zone to the next. The challenge with multilateral completion is to install a junction apparatus having adequate internal and external pressure capability without relying only on the strength of the local rock formations.

Prior art junction apparatus designs are based on a low angle side branch casing connected to a window on the main borehole casing. Prior proposals generally require in situ milling of a window or a section in the main borehole casing. Milling steel casing downhole is a difficult task. Also, while there are numerous proposals for sealing the branch liner casing to the window, improvements are needed. One design deforms a complete junction assembly to offer a diameter equal or less than the diameter of the main borehole casing and expanding it in situ to the full cylindrical shape. In that design, the junction assembly may be elastomeric or memory metal. The junction assembly is expanded within an enlarged section of the well formed after a section of the casing is milled out.

Due to the side window based connecting link between the main borehole casing and the branch outlet, all these configurations offer poor internal pressure capacity and even more limited collapse capability when the junction is located in unconsolidated or weakly consolidated formations. The poor internal pressure capability and resistance to collapsing exists even when they are fully cemented since cement does not work well in traction. It is therefore highly desirable to have a junction apparatus offering good internal pressure and collapse capability to permit a wide freedom in the location of lateral junction independent from the strength of the cementing job and/or surrounding rock formation.

Disclosure of Invention

In this invention, a casing junction member or apparatus is provided which an upper end which connects into the main casing. A lower main end connects to the lower main casing extending into the well. The junction apparatus has a lateral branch section which is at an angle relative to the longitudinal axis of the main section.

The lateral and lower enlarged sections join each other at a junction which has a lower

perimeter portion that is generally in the shape of parabola. In one embodiment, a stiffening plate or rib is located at this junction. The plate is located in a plane of the perimeter portion and is joined between the lateral and lower enlarged sections.

Preferably the junction apparatus has an upper enlarged section which is conical and joins the upper end section of the main section. The conical upper enlarged section diverges in a downward direction. A conical lower enlarged section joins the lower end of the upper enlarged section and extends downward to the lower end section of the main section. The conical lower enlarged section diverges in a downward direction. A generally conical lateral section joins the upper enlarged section also and extends downward to the lower end section of the lateral section. The conical lateral section also converges in a downward direction. The conical lower enlarged and lateral sections are truncated. Only their inner sides join each other at the junction.

In the preferred method of installation, the junction apparatus is of steel and is plastically deformable from a collapsed position to a set position. In the collapsed position, the junction apparatus has a diameter no greater than the main casing collar. The main bore is drilled and underreamed at an intersection depth. The junction apparatus is connected to the main casing and lowered into the well with the main casing. After reaching the underreamed section, fluid pressure is applied to the main casing to cause the junction apparatus to move to the set configuration. Then the main casing is cemented in place, with the cement also flowing around the junction apparatus in the underreamed section of the borehole. Subsequently, the lateral bore is drilled and a lateral casing liner installed and sealed to the lateral section of the junction member.

<u>Brief Description of the Drawings</u>

Figure 1 is a side elevational view illustrating a junction apparatus connected into a main string of casing and shown in a collapsed position.

Figure 2 is a side elevational view similar to Figure 1, but showing the junction apparatus expanded to a set position.

Figure 3 is a sectional view of the junction apparatus of Figure 1, taken along the line 3-3 of Figure 1.

Figure 4 is a sectional view similar to Figure 3, but taken along the line 4-4 of Figure 2 to show the apparatus in the set position.

Figure 5 is a sectional view of the junction apparatus of Figure 1, taken along the line 5-5 of Figure 1.

Figure 6 is a sectional view similar to Figure 5, but taken along the line 6-6 of Figure 2 to show the apparatus in the set position.

Figure 7 is a sectional view of the junction apparatus of Figure 1, taken along the line 7-7 of Figure 1.

Figure 8 is a sectional view similar to Figure 7, but taken along the line 8-8 of Figure 2 to show the apparatus in the set position.

Figure 9 is a sectional view of the junction apparatus of Figure 1, taken along the line 9-9 of Figure 1.

Figure 10 is a sectional view similar to Figure 9, but taken along the line 10-10 of Figure 2 to show the junction apparatus in the set position.

Figure 11 is a sectional view of the junction apparatus of Figure 1, taken along the line 11-11 of Figure 1.

Figure 12 is a view similar to Figure 11, but taken along the line 12-12 of Figure 2 to show the junction apparatus in the set position.

Figure 13 is a sectional view of the junction apparatus of Figure 1. taken along the line 13-13 of Figure 1.

Figure 14 is a sectional view similar to Figure 13, but taken along the line 14-14 of Figure 2 to show the junction apparatus in the set position.

Figure 15 is a sectional view of the junction apparatus of Figure 1, taken along the line 15-15 of Figure 1.

Figure 16 is a sectional view similar to Figure 15, but taken along the line 16-16 of Figure 2 to show the junction apparatus in the set position.

Figure 17 is an enlarged vertical sectional view of the junction apparatus of Figure 1, shown in the set position.

Figure 18 is a perspective view of the junction apparatus of Figure 1.

Figure 19 is a sectional view of the junction apparatus of Figure 1, taken along the line 19-19 of Figure 18.

Figure 20 is a sectional view similar to Figure 11, but showing an alternate embodiment of the junction apparatus.

Figure 21 is a side view of another embodiment of a junction apparatus constructed in accordance of this invention and shown in the collapsed position.

Figure 22 is a side view of the junction apparatus of Figure 21, shown in the set position.

Figure 23 is an enlarged side view of a segmented rod employed with the junction apparatus of Figure 21.

Figure 24 is a sectional view of the junction apparatus of Figure 21, taken along the line 24-24 of Figure 21.

Figure 25 is a sectional view of the junction apparatus of Figure 21. taken along the line 25-25 of Figure 22.

Figure 26 is a sectional view of the junction apparatus of Figure 21. taken along the line 26-26 of Figure 21.

Figure 27 is a sectional view of the junction apparatus of Figure 21, taken along the line 27-27 of Figure 22.

Figure 28 is a sectional view of the junction apparatus of Figure 21. taken along the line 28-28 of Figure 21.

Figure 29 is a sectional view of the junction apparatus of Figure 21. taken along the line 29-29 of Figure 22.

Figure 30 is a sectional view of the junction apparatus of Figure 21, taken along the line 30-30

of Figure 21.

Figure 31 is a sectional view of the junction apparatus of Figure 21, taken along the line 31-31 of Figure 22.

Figure 32 is a sectional view of the junction apparatus of Figure 21, taken along the line 32-32 of Figure 21.

Figure 33 is a sectional view of the junction apparatus of Figure 21, taken along the line 33-33 of Figure 22.

Figure 34 is a sectional view of the junction apparatus of Figure 21, taken along the line 34-34 of Figure 21.

Figure 35 is a sectional view of the junction apparatus of Figure 21, taken along the line 35-35 of Figure 22.

Figure 36 is a sectional view of the junction apparatus of Figure 21, taken along the line 36-36 of Figure 21.

Figure 37 is a sectional view of the junction apparatus of Figure 21, taken along the line 37-37 of Figure 22.

Figure 38 is a sectional view of the junction apparatus of Figure 21 within a folding machine in preparation for being folded, and taken along the line 38-38 of Figure 40.

Figure 39 is a sectional view showing the junction apparatus and folding machine of Figure 38 after folding has occurred.

Figure 40 is a side view of the folding machine of Figure 38, shown prior to folding.

Figure 41 is a sectional view showing the junction apparatus of Figure 21 positioned in a collapsing machine for collapsing from the folded position of Figure 21, and taken along the line 41-41 of Figure 43.

Figure 42 is a sectional view illustrating the junction apparatus and the collapsing machine of Figure 40 moved to the collapsed position.

Figure 43 is a side view of the collapsing machine of Figure 41, shown prior to collapsing the junction apparatus.

Best Mode for Carrying Out the Invention

Referring to Figure 1, a main bore 11 has been drilled. At a desired intersection depth, an enlarged diameter section 13 is created by underreaming. A string of main casing 15 has been run into main bore 11 through enlarged section 13. Enlarged section 13 is created at a desired intersection depth to start a lateral branch bore.

A first embodiment of a junction member 17 is connected into main casing 15 at the surface and lowered into enlarged section 13 while running casing 15. Junction member 17 is in a collapsed position while running in, as shown in Figure 1. Subsequently, it will be expanded by internal fluid pressure to the set position in Figure 2. Junction member 17 is of steel of a high elongation grade which is capable of being plastically deformed into the collapsed position and expanded under fluid pressure to the set position.

Junction member 17 includes an upper end section 19 which is secured to a casing collar 20 of

main casing 15. Upper end section 19 is a cylindrical section which is coaxial with a main bore axis 23. An upper enlarged section 21 is joined to upper end section 19, preferably by welding. Upper enlarged section 21 is a conical member which diverges or increases in diameter in a downward direction, as can be seen by comparing Figures 6 and 8 and viewing Figures 18 and 19. Upper enlarged section 21 is a right circular cone generated about an axis 22. Cone axis 22 intersects and is inclined at a slight angle relative to main bore axis 23. Similarly, a lateral branch axis 25 is inclined slightly and intersects main bore axis 23 at the same point of intersection as cone axis 22. Cone axis 22 is one-half the angle of intersection of lateral axis 25. The angles of intersections may differ from well to well, and in the embodiment shown, lateral axis 25 is at a 10 deg. angle relative to main axis 23, while cone axis 22 is at a 5 deg. angle. The upper section of the lateral branch wellbore (not shown) will be drilled along lateral axis 25.

A lower enlarged conical section 27 joins the lower end of upper enlarged section 21, such as by welding. Lower enlarged conical section 27 is also a right circular cone that is slightly tilted relative to main axis 23. When viewed in the elevational view of Figure 2, the left sides of conical upper enlarged section 21 and lower enlarged section 27 appear flush with each other and in a straight line with a side of main casing 15. Lower enlarged conical section 27 diverges in a downward direction, having a decreasing diameter as shown in Figures 18 and 19.

A lateral conical section 29, identical to lower enlarged conical section 27, also joins upper enlarged section 21, such as by welding. Lateral conical section 29 is also a section of right circular cone which is tilted relative to main axis 23 and lateral axis 25. When viewed in the elevational view of Figure 2, a right side portion of lateral conical section 29 appears flush with a right side section of upper enlarged section 21 and parallel to lateral axis 25. Lateral conical section 29 also diverges in a downward direction, having a decreasing diameter as shown in Figure 18.

Referring to Figures 17-19, inner side portions of lower enlarged conical section 27 and lateral conical section 29 are cut or truncated to form a junction of the two sections. This junction has a lower perimeter portion 31 that is in a configuration of a parabola. Lower perimeter portion 31 comprises mating edges of lower enlarged and lateral conical section 27, 29, the edges being abuttable with each other. Lower perimeter portion 31 is contained in a plane that contains cone axis 22.

In the first embodiment, a stiffening plate or rib 33 is sandwiched between the conical lower enlarged and lateral sections 27, 29 at lower perimeter portion 31. Stiffening plate 33 is also in the general configuration of a parabola. In the embodiment shown, it has an inner edge 35 that is in the configuration of a parabola. Outer edge 37 is also in the configuration of a parabola. However, the parabola of inner edge 35 is not as steep, with edges 35, 37 converging toward each other in an upward direction. This results in legs 38 for stiffening plate 33 that decrease in width in an upward direction until reaching a minimum width at upper ends 39. Upper ends 39 of stiffening plate 33 are located at the lower end of upper enlarged section 21. The width between inner edge 35 and outer edge 37 is the smallest at this point. The maximum width of plate 33 is at its lowest point.

Stiffening plate 33 is welded to lower enlarged and lateral conical members 27, 29 at junction 31. In this position, inner edge 35 is located above lower perimeter portion 31, while outer edge 27 is

located below lower perimeter portion 31. Stiffening plate 33 is located in a plane of lower perimeter portion 31. Conical axis 22 passes through a plane containing stiffening plate 33.

The purpose of stiffening plate 33 is to reinforce the junction between lower enlarged and lateral conical sections 27, 29. Referring to Figures 10 and 12, internal pressure within junction member 17 will tend to cause junction member 17 to assume a circular configuration. The circular configuration is desired at the lower edge of upper enlarged section 21 as shown in Figure 10. However, the junction of the lower enlarged and lateral conical sections 27, 29 with upper enlarged section 21 is not circular, as shown in Figure 12. In Figure 12, which is a section taken about halfway down the joined lower enlarged and lateral conical sections 27, 29, the joined conical sections will have a cross-sectional configuration that is not circular. Rather, the distance 40 between outer sides of the lower enlarged and lateral conical sections 27, 29 perpendicular to a line extending between legs 38 is substantially greater than the distance between the two legs 38 of stiffening plate 33 at that point. The cross-section presents a general peanut shape, with the dotted lines in Figure 12 representing the full bore access to the lower ends of the main and lateral branches. Without stiffening plate 33, internal pressure would tend to force the small dimension portion between legs 38 apart to the circular configuration as in Figure 10. This would deform the junction and restrict the full bore access to both branches. Stiffening plate 33 prevents such occurrence at test pressure levels.

Referring again to Figure 2, a cylindrical main section lower end 41 joins the lower end of lower enlarged conical section 27, which is circular at that point. The main section lower end 41 is secured to the lower continuation of main casing 15 by a threaded collar. Lower end 41 is coaxial with main axis 23. Similarly, cylindrical lateral end portion 43 joins the lower end of lateral conical section 29, which is circular at that point. Lateral section 43 extends downward and provides a guide for drilling a lateral branch borehole (not shown). Lateral end section 43 is coaxial with lateral axis 25. Stiffening plate 33 extends downward a short distance between main section lower end 41 and lateral section lower end 43.

Junction member 17 if first constructed and tested in the set configuration, then will be formed in the collapsed configuration that is shown in Figure 1. In the collapsed configuration, the overall diameter is substantially the same as the diameter of main casing 15 and no greater than the outer diameter of casing collar 20. Referring to Figure 1 and Figures 3, 5, 7, 9, 11, 13 and 15, the collapsed configuration has a doubled back section 45 within upper enlarged section 21. Doubled back section 45 increases in extent in a downward direction as shown by comparing Figure 5, Figure 7 and Figure 9.

As shown in Figure 11, lower enlarged conical section 27 remains generally undeflected. However, lateral conical section 29 is folded into the interior of lower enlarged conical section 27. In the position shown, two loops 47 are employed to accommodate the full extent. Note that legs 38 will not be in a common plane in the collapsed position. In Figure 13, an inner side 49 of main lower end 41 is doubled back into an outer side section of main lower end 41, presenting a crescent shape.

A plurality of axially extending channels 51 are formed in the upper section of lateral section lower end 43. Stiffening plate 33 is bent into a concave configuration at its lower section. Referring to Figure 15, more vertical channels 51 will be present on lateral section lower end 43, and they will be

symmetrical to form a corrugated configuration for lateral section lower end 43. The crescent configuration remains for main section lower end 41 for a short distance downward where it again returns to a cylindrical configuration as shown in Figure 1. In the collapsed position, lateral end section 43 extends downward generally parallel with main axis 23.

In operation, main bore 11 will be drilled, then one or several enlarged sections 13 are created. The operator inserts one or several junction members 17 into main casing 15 while in the collapsed position and runs main casing 15. Main casing 15 will have a conventional cementing shoe (not shown) on its lower end. The cement shoe will be of a type which prevents downward flow until a dart or ball is dropped to shift a valve member. Lateral end 43 has a plug 52 which seals both while lateral end 43 is in the corrugated shape and in the set position.

When junction member 17 reaches enlarged bore section 13, the operator will apply pressure to casing 15. The internal pressure causes junction member 17 to plastically deform from the collapsed position shown in Figure 1 to the set position shown in Figure 2. The operator then drops a ball or dart to shift cement shoe to a position wherein fluid may be pumped downward in main casing 15. The operator then pumps cement down main casing 15, which flows out the cement shoe and back up an annulus in main bore 11 surrounding main casing 15. The cement will flow through the enlarged section 13 and up toward the surface. Drilling fluid will be pumped down behind the cement to flush main bore casing 15 of cement. A cement wiper plug (not shown) separates the cement from the drilling fluid, the plug moving downward through junction member 17 to the lower end of main bore casing 15.

The operator may then perform further drilling through main casing 15. When the operator wishes to drill the lateral branch, he will either install a whipstock in the main borehole or use a kick-out device to deflect the drill bit over into the lateral section. The operator drills out plug 52 and continues drilling at lateral angle 25 for a selected distance into the earth formation. Once a desired depth has been reached for the lateral branch, the operator will run a liner casing (not shown). The liner casing will have a conventional hanger and seal for hanging and sealing within lateral section lower end 43. The lateral liner casing will be cemented in a conventional manner.

Figure 20 illustrates an alternate embodiment in which the walls of the junction apparatus are formed with multiple plies, each being metal, to facilitate expansion from the collapsed position to the set position. For example, Figure 20 shows an inner wall or ply 53 located within an outer ply or wall of conical members 27' and 29'. The stiffening plate is also formed of multiple plies as indicated by legs 38'. The total thickness of the two plies should be substantially no greater than that of a single wall which has the same pressure rating. The use of two walls for the various components of junction member 17 reduces the amount of strain that would otherwise occur during plastic deformation with a single wall having the same total thickness as the two plies.

Figures 21-40 illustrate another embodiment of a junction member, with the principal difference between junction member 55 does not use a stiffening plate such as stiffening plate 33 (Fig. 2). Referring to Figure 22, junction member 55 has an upper end section 57 that is cylindrical and of the same diameter as a main string of casing (not shown) for attachment to the main string of casing. A

conical upper enlarged section 59 has an upper end welded to the lower end of upper end section 57. Upper enlarged section 59 diverges in a downward direction, resulting in a greater diameter at its lower end at section line 31 than at its upper end above section line 25. Upper enlarged section 59 has an axis 61 which is inclined relative to main casing axis 63.

A conical lower enlarged section 65 has an upper end welded to part of the lower end of upper enlarged section 59. Conical lower enlarged section 65 is much shorter in length than the length of upper enlarged section 59. Conical section 65 converges in a downward direction, as can be seen by comparing Figures 33 and 35, and comprises one-half of a cone with a diameter at its lower end that is substantially the same as the diameter of the upper end section 57.

A conical lateral section 67 also joins the lower end of upper enlarged section 59. Conical lateral section 67 is the same length as conical lower enlarged section 65, but of a lesser diameter. Referring to Figure 33, conical lateral section 67 forms the right half of junction member 55 at section line 33, with conical lower enlarged section 65 forming the left half at that point. Conical lower enlarged section 65 and lateral section 67 are truncated and abutted along their inner edges 68, the inner edges 68 being in a plane which contains axis 61 of upper enlarged section. Inner edges 68 of the conical lower enlarged section 65 and conical lateral section 67 are welded together.

In the first embodiment, a stiffening plate 33 is located between the inner edges, while in this embodiment, it is not required due to the relatively short lengths of conical lower enlarged and lateral sections 65, 67. As shown in Figure 33, the shape of junction member 55 at that point is somewhat in the shape of a peanut, with a major dimension 69 that is greater than a minor dimension measured perpendicular to line 69 at the midpoint of line 69.

Referring again to Figure 22, a lower main section 71 of cylindrical configuration is welded to the lower end of conical lower enlarged section 65. Lower main section 71 joins main casing (not shown) extending below and is coaxial with upper main section 57 and main axis 63. A lower lateral section 73 of cylindrical configuration is welded to the lower end of conical lateral section 67. Lower lateral section 73 will receive a string of lateral liner (not shown). Junction member 55 while in the expanded position resembles an inverted "Y". A drillable plug 75 is secured in lower lateral section 73. The diameter of lower lateral section 73 is smaller than the diameter of lower main section 71. Lower lateral section 73 is located on a lateral branch axis 77 which is at an acute angle relative to main casing axis 63. Upper enlarged section axis 61 bisects axes 63 and 77, with all three axes 61, 63, 77 being in a single plane.

For manufacturing purposes, a segmented rod 79 is secured to junction apparatus 55. Segmented rod 79 has two portions 79a, 79b, each located on the exterior of junction member 55 180 deg. apart from the other. Segmented rod portions 79a, 79b are identical and are used when deforming junction member 55 from the set position of Figure 22 to the collapsed position of Figure 21, as will be subsequently explained. Figure 23 shows segmented rod 79 prior to installation. Each segmented rod portion 79a, 79b has an upper end 81 which is tack welded to exterior portion of junction member 55 near the upper end of upper enlarged section 59. The middle section 83 of segmented rod 79 loops under the lower end of the intersection of the conical lower enlarged section 65 and conical lateral

section 67. Each segmented rod portion 79a, 79b is located in a plane that contains upper enlarged section axis 61.

Junction member 55 will first be formed and tested in the expanded configuration of Figure 22 or in the folded configuration of Figure 39 with some external support. Then it will be collapsed to the position shown in Figure 21 for passage into the well. Referring to Figures 38 and 40, in the first step, junction member 55 will be positioned on a folding machine 90 which extends from the lower end of lower lateral section 73 to upper end section 57 (Fig. 22). Folding machine 90 has two opposed convex, blunt blades 91, 93. Blades 91 are hinged together by a hinge 92 at the end near upper end section 57. Folding machine 90 has two stationary retainers or supports 87, 89. Figures 38 and 39 are taken at a section similar to the section shown in Figures 30 and 31.

For reference, assume that blades 91, 93 are at the 0 deg. and 180 deg. position, while retainers 87, 89 are stationarily mounted at the 90 deg. and 270 deg. position. The lateral leg or lower lateral section 73 will be located at the 90 deg. position and held in place by stationary support 87. Then, blades 91, 93 are moved toward each other by hydraulic force until a point on the inner diameter at the 0 deg. position contacts a point on the inner diameter at the 180 deg. position. This step folds junction member 55 into two halves, forming two concave bights 94. Note by comparing Figures 24, 26, 28 and 30, that blades 91, 93 do not form bights 94 of constant depth. The distance between blades 91, 93 at hinge 92 and the conical configuration of junction member 55 creates shallower bights 94 at the upper end, with the inner sides of junction member 55 touching only in the proximity of section line 31 (Fig. 22).

Then, as shown in Figure 41, segmented rod 79 is secured in the bights 94, with the middle portion 83 looped between lower lateral sections 73 and lower main section 71. The upper ends 81 will be tack welded in the bights 94. As shown in Figures 26, 28 and 30, the distance between segmented rod portions 79a, 79b gradually increases in the upward direction from the lower end of upper enlarged section 59 to the upper ends 81 generally at section line 26 (Fig 26).

Returning to Figures 41 and 43, junction member 55 is then placed in a collapsing machine 96. Collapsing machine 96 has two concave dies 95, 97 which are semicylindrical, forming a cylinder when brought together as in Figure 42. The inner diameter of dies 95, 97 is substantially the same as the outer diameter of upper end section 19 collar 20 (Fig. 1). Concave dies 95, 97 are located at the 90 deg. and 270 deg. position and connected by a hinge 98 at the upper end as shown in Figure 43. Figures 41, 42 are also shown at a section line at the lower end of upper enlarged section 59, this section line being shown in Figure 30.

Die 95 is hydraulically moved toward die 97, causing the two lobes opposite bights 94 to collapse into configuration shown in Figure 42. In this configuration, junction member 55 has an outer diameter, or cylindrical surface of revolution, which is no greater than collar 20 of upper end section 57 or 19. As can be seen in Figures 32 and 34, die 95 folds lower lateral section 73 inward into a concave depression formed in lower main section 71. Lower main section 71 will be crescent-shaped, while lower lateral section 73 remains mostly cylindrical and substantially undeflected. As shown by dotted lines 99 in Figure 36, the surface of revolution of junction member 55 is cylindrical and no greater at

any point than the outer diameter of collar 20 (Fig. 1). Segmented rod portions 79a, 79b limit strain during the bending of bights 94, preventing them from forming curved portions which are too small in ~~radius~~.

~~Junction apparatus 55 is run and installed in the same manner as described~~ in connection with the first embodiment. It is run in while in the collapsed position of Figure 21. Junction member 55 will locate within a reamed out section of the borehole. Hydraulic pressure is supplied to liquid contained in the main casing and junction apparatus 59. A plug (not shown) at the cement shoe at the lower end of the main casing enables hydraulic pressure to be applied throughout the length of casing and junction apparatus 55. The pressure causes junction member 55 to expand to the set position with lateral leg 73 moving outward.

After reaching this position, a valve will be shifted at the cement shoe to enable cement to be pumped downward, which flows through the main casing and back up at annulus surrounding the main casing. When it is desired to drill the lateral well bore, the operator uses a kick-off tool or whipstock to cause bit to enter lateral leg 73, drill-out plug 75 and drill the lateral leg. Lateral casing of smaller diameter than the main casing will be run through lateral leg 73 and supported by a hanger mechanism in lateral leg 73. Lateral casing will be cemented conventionally.

The invention has significant advantages. The junction apparatus provides a good seal between the main casing and the lateral branch casing. The junction member may be run in collapsed and expanded to a set position. The method of running the junction member in with the main casing avoids a need to mill out a window or section of the main casing. In the second embodiment, there is not need to plastically deflect greatly the cylindrical part of the lateral leg, facilitating a plug to be located therein.

While the invention has been shown in only one of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention. For instance the conical sections can be replaced by an extended stiffening plate. Also the bottom of upper enlarged section 21 can be large enough to accommodate full access to both branches side by side, and the stiffening plate inner edge 35 can be straight without any legs 38.

I claim:

1. A casing junction apparatus for joining a lateral branch casing to a string of main casing in a well, the apparatus having a collapsed position for running-in and an expanded position while installed, the apparatus comprising:

a main passage having an upper end and a lower end adapted to be secured into and run with a string of main casing into a main well while the apparatus is in the collapsed position;

a lateral passage joining the main passage between the upper and lower ends and extending laterally therefrom; and wherein the apparatus is formed of malleable material and has

a removable or drillable closure member blocking the lateral passage while in the collapsed position and the expanded position.

2. The apparatus according to claim 1 wherein the apparatus is formed of metal and is movable from the collapsed position to the expanded position in response to internal fluid pressure applied to the main and the blocked lateral passages.

3. The apparatus according to claim 1 wherein the closure member is a drillable cement shoe.

4. The apparatus according to claim 1 wherein the wall of the lateral passage is corrugated to reduce its diameter and the closure member is housed in the corrugated section.

5. The apparatus according to claim 1, wherein while in the collapsed position, the apparatus has a general cylindrical configuration coaxial with the main axis.

6. The apparatus according to claim 5, wherein while in the collapsed position, the apparatus has a general cylindrical diameter close to the casing collar diameter.

7. The apparatus according to claim 1 wherein the main passage comprises:

a generally conical upper enlarged section which is adapted to be connected to main casing above the apparatus and diverges in a downward direction;

a generally conical lower enlarged section which joins the upper enlarged section and extends downward, the conical lower enlarged section converging in a downward direction for connection to main casing below the apparatus; and

the lateral passage comprises a branch lateral section which joins at least one of the enlarged sections and extends downward at an angle relative to the main casing for connection to lateral branch casing below the apparatus.

8. The apparatus according to claim 1, wherein the main passage comprises also:

a cylindrical main lower end section which is adapted to be secured to the lower portion of the main casing;

and the lateral passage comprises also a cylindrical lateral lower end section which is adapted to be secured to the lateral branch casing, and wherein

while in the collapsed position, the cylindrical main lower end section deforms into a doubled back configuration to receive the cylindrical lateral lower end section, which remains substantially undeflected in a generally cylindrical configuration.

9. The apparatus according to claim 7, wherein some portion of the lower enlarged section and the lateral section has multiple ply metal walls section.

10. The apparatus according to claim 7, wherein the lower enlarged section and the branch lateral section are partially conical and have a junction which has a lower perimeter portion that is generally in the shape of a parabola

11. The apparatus according to claim 10, wherein the apparatus further comprises: a stiffening member joined to the lower perimeter portion of the junction, the stiffening member being located in a plane containing the lower perimeter portion of the junction.

12. A method for providing a junction in a main casing to enable a lateral branch well to be drilled therefrom, comprising:

(a) providing a metal junction apparatus which has a single upper end, a main leg portion and a lateral leg portion, defining a generally inverted Y-shape;

(b) deforming the junction apparatus into a collapsed position in which the main leg portion receive the lateral leg portion;

(c) blocking the lateral leg portion with a removable or drillable closure;

(d) securing the junction apparatus into the main casing, and running the main casing and the junction apparatus into a well; and

(e) pumping a liquid into the main casing at a pressure sufficient to cause the junction apparatus to expand into the inverted Y-shape, with the lateral leg portion moving laterally outward.

13. The method according to claim 12, wherein step (d) further comprises closing a lower end of the main casing with a cement shoe; and wherein after step (e), the method further comprises, opening the cement shoe and pumping cement down the main casing which flows back up an annulus in the well surrounding the main casing.

14. The method according to claim 12, wherein the method comprises after pumping cement down the main casing:

lowering a drill bit into the lateral leg portion;

drilling out the closure member contained therein;

drilling a lateral well through the lateral leg portion; then

running a lateral string of casing through the lateral leg portion and securing an upper end of the lateral string of casing to the lateral leg portion.

15. The method according to claim 12, wherein step (b) comprises:

forming opposite portions of a sidewall of the main leg portion inward into contact with each other, forming concave bights at zero and 180 degrees, with reference to the lateral leg section being at 90 degrees; then

placing radius limiting rods in each bight; then

bending the lateral leg section and the main leg toward each other with concave dies to form a generally cylindrical shape.

16. The method according to claim 12, further comprising:

prior to installing the main casing and the junction apparatus in the well, enlarging an intersection portion of the well; and

performing step (e) while the junction apparatus is in the intersection portion of the well; then after step (e),

pumping a cement slurry down the main casing and back up an annulus surrounding the main casing and around the junction apparatus; then

drilling a lateral branch wellbore through the lateral leg section of the junction apparatus; and then

running lateral branch casing into the lateral branch wellbore and securing an upper end of the lateral branch casing to the lateral leg of the junction apparatus.

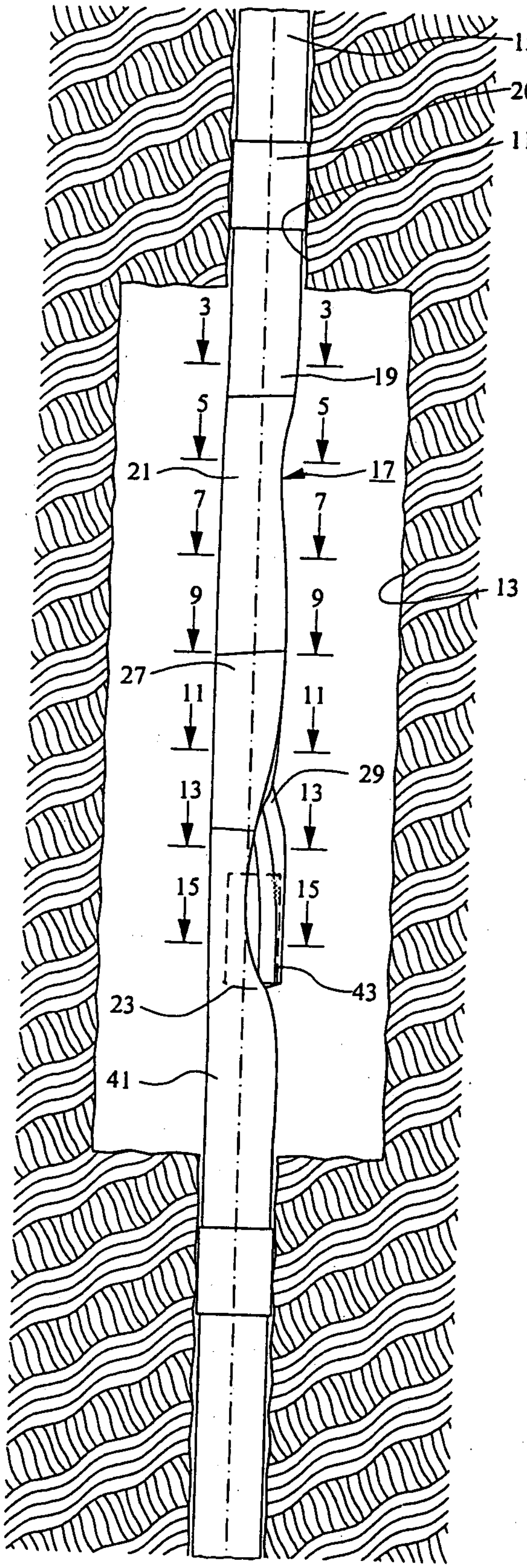

15
20
11
3
3
19
5
5
21
17
7
7
9
9
13
27
11
11
29
13
13
15
15
23
43
41

Fig. 1

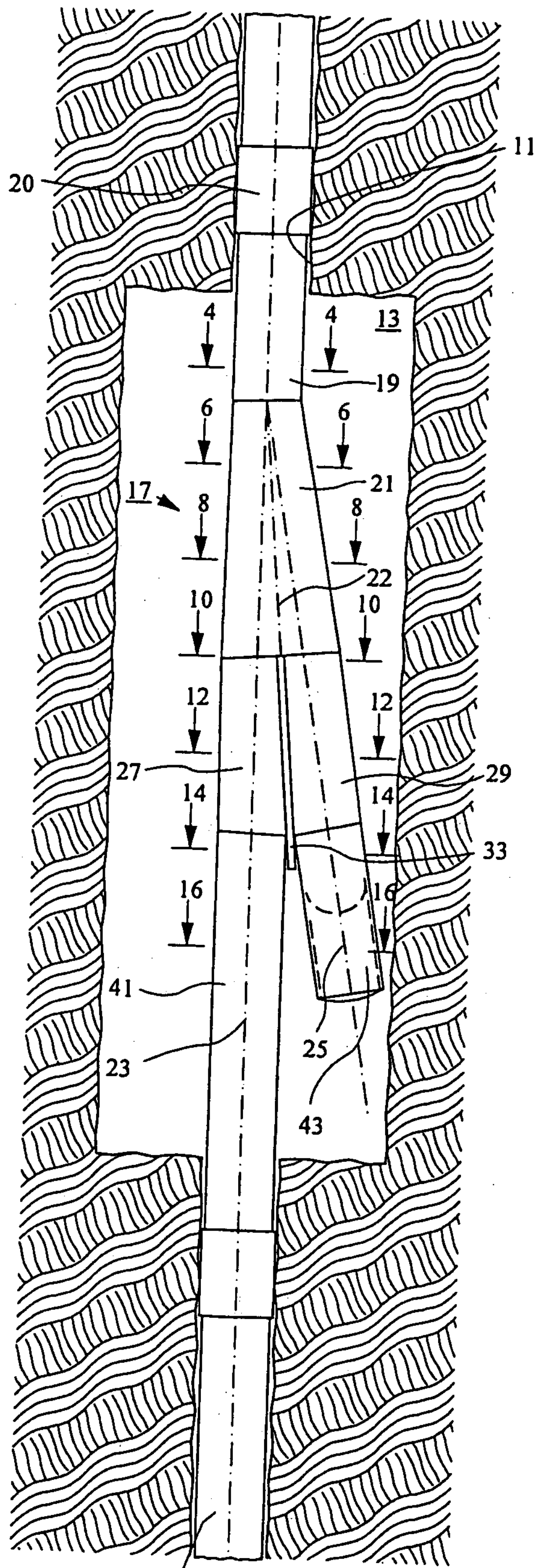

11
20
4
4
13
19
6
6
21
17
8
8
22
10
10
12
12
27
29
14
14
33
16
16
41
23
25
43
15

Fig. 2

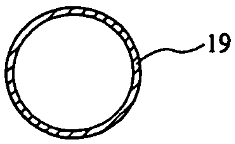


Fig. 3

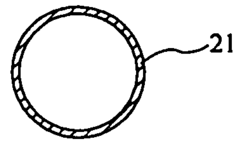


Fig. 4

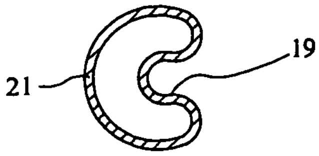


Fig. 5

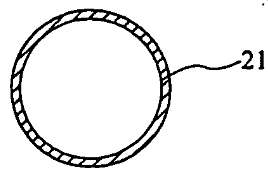


Fig. 6

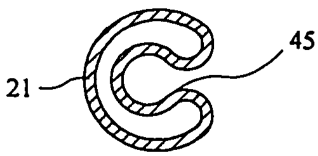


Fig. 7

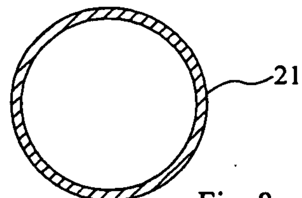


Fig. 8

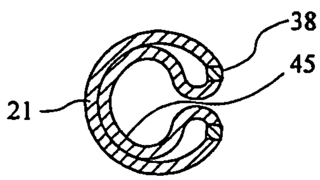


Fig. 9

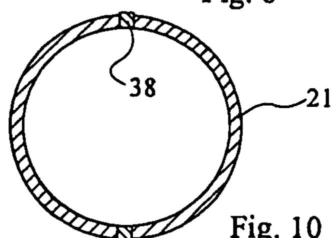


Fig. 10

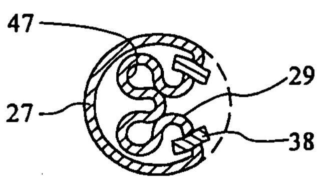


Fig. 11

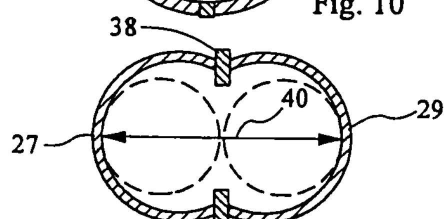


Fig. 12

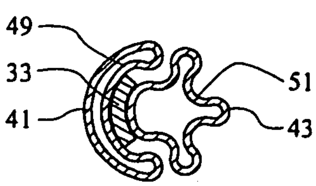


Fig. 13

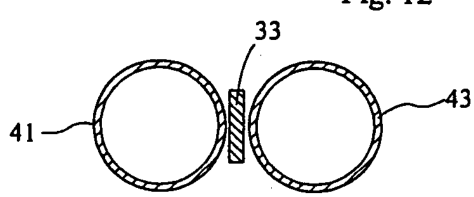


Fig. 14

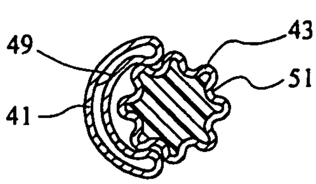


Fig. 15

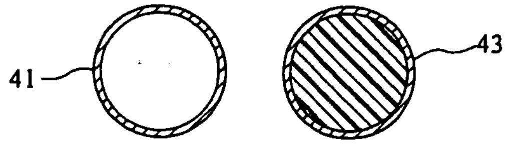


Fig. 16

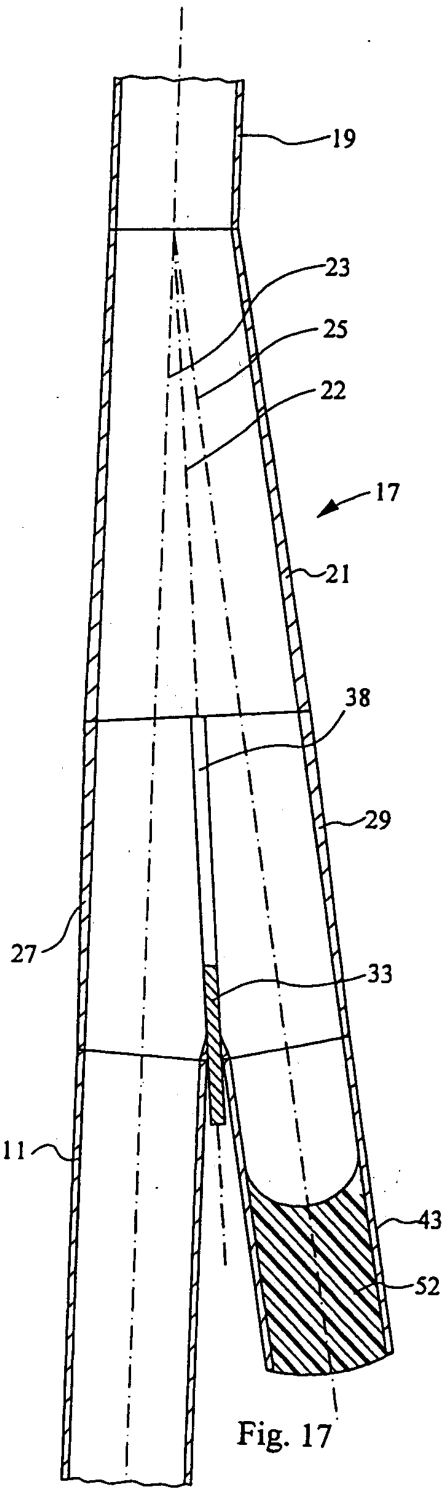


Fig. 17

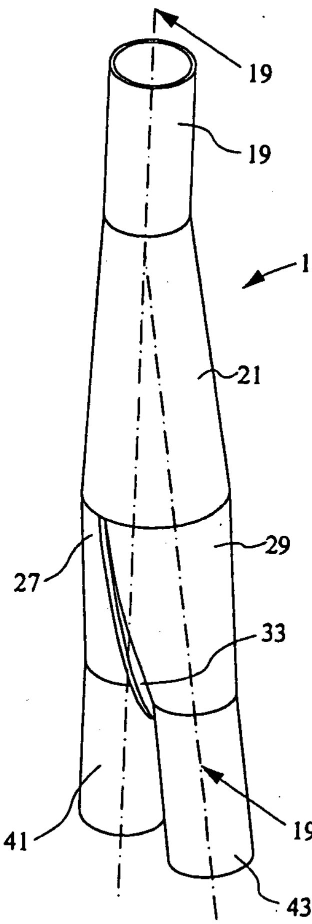


Fig. 18

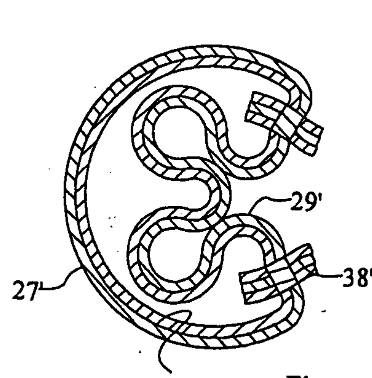


Fig. 20

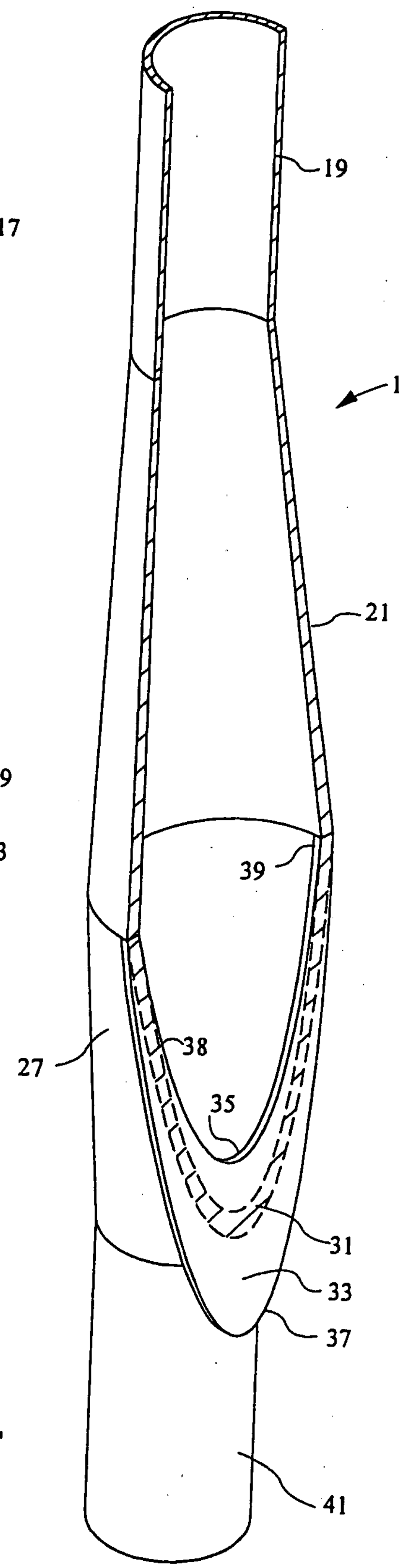


Fig. 19

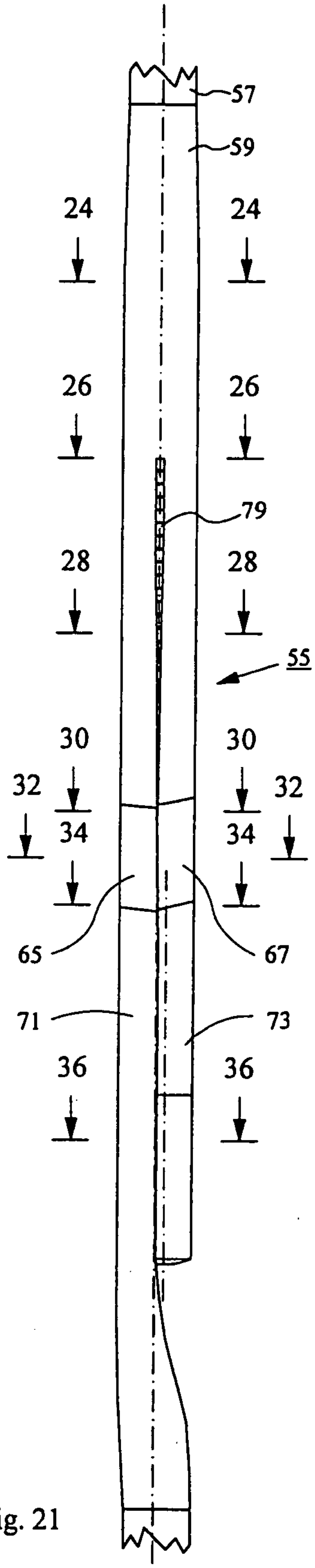


Fig. 21

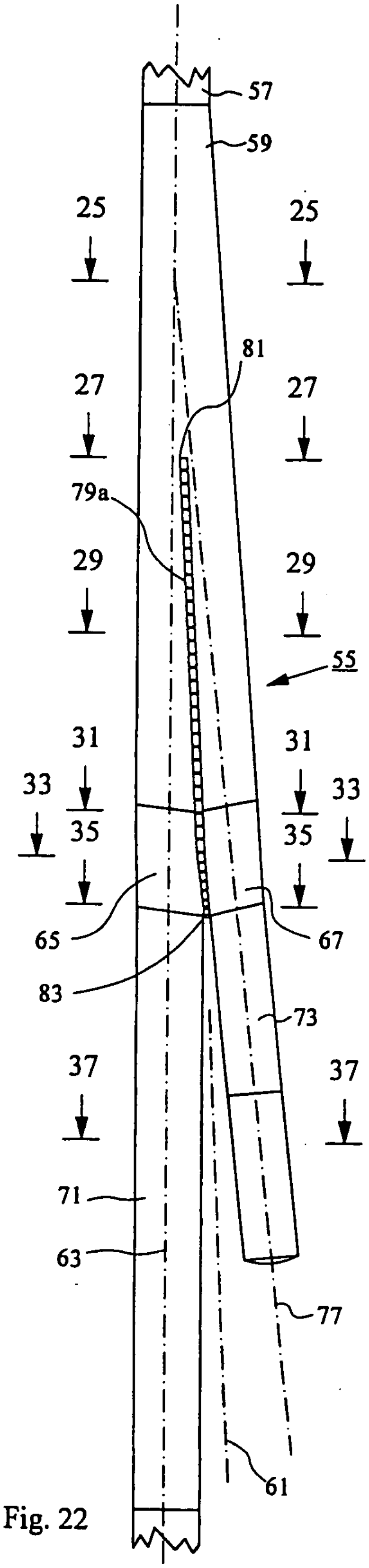


Fig. 22

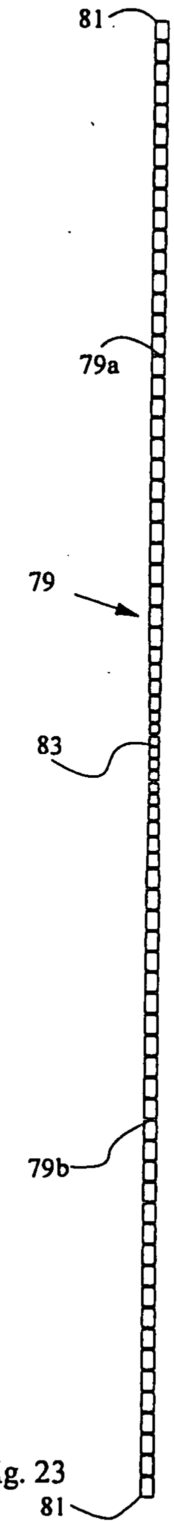


Fig. 23

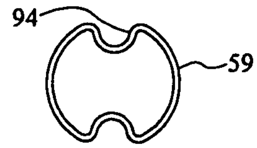


Fig. 24

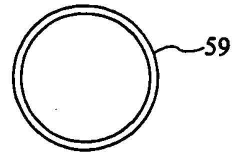


Fig. 25

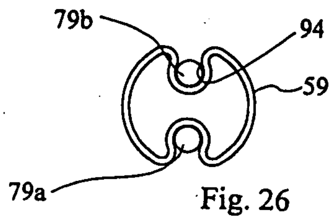


Fig. 26

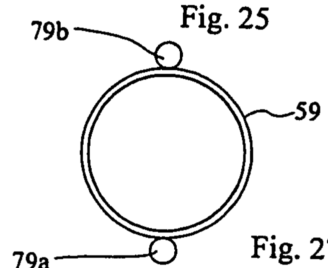


Fig. 27

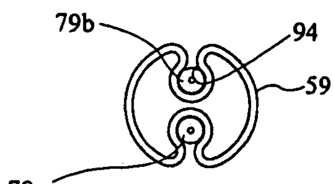


Fig. 28

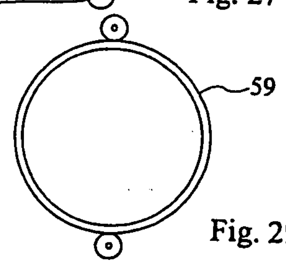


Fig. 29

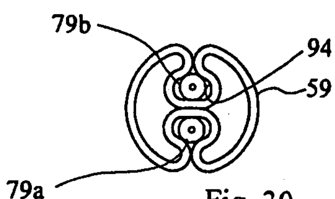


Fig. 30

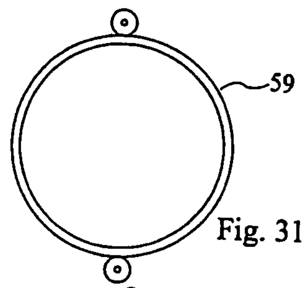


Fig. 31

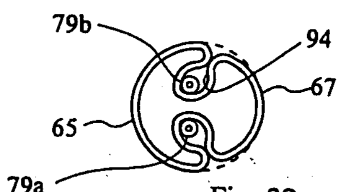


Fig. 32

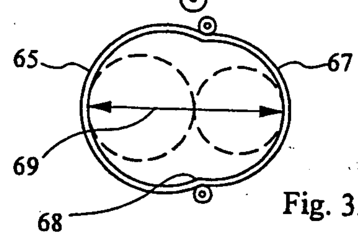


Fig. 33

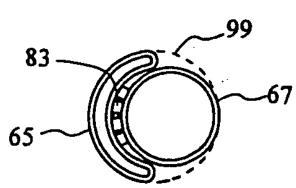


Fig. 34

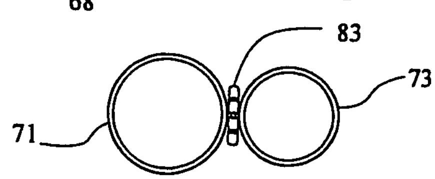


Fig. 35

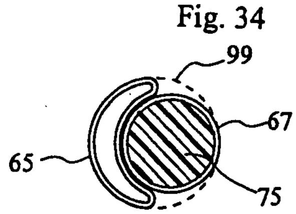


Fig. 36

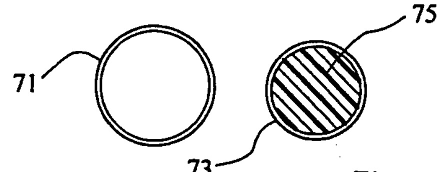


Fig. 37

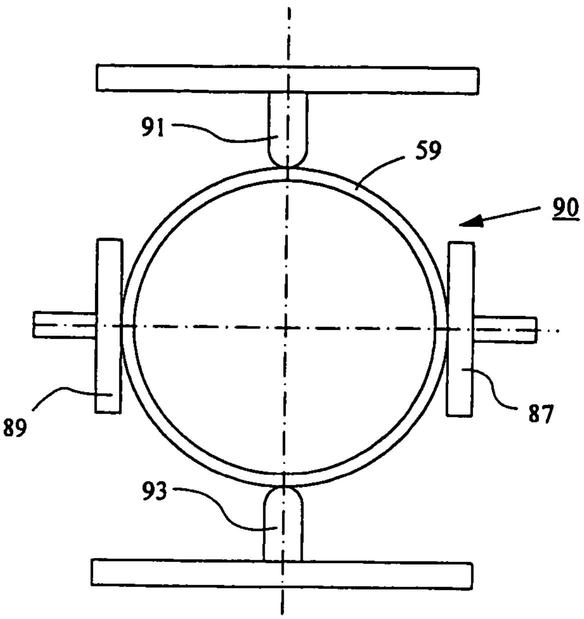


Fig. 38

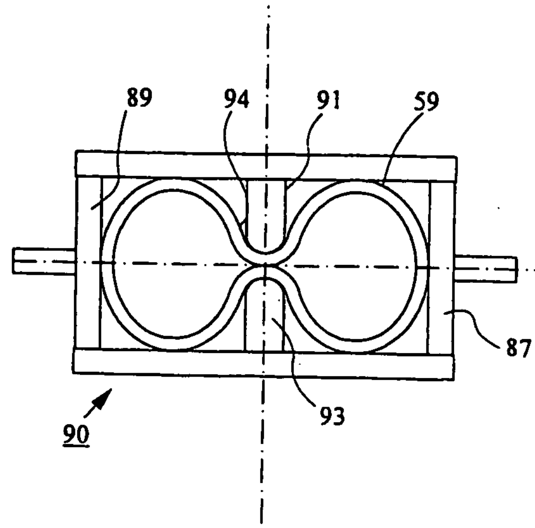


Fig. 39

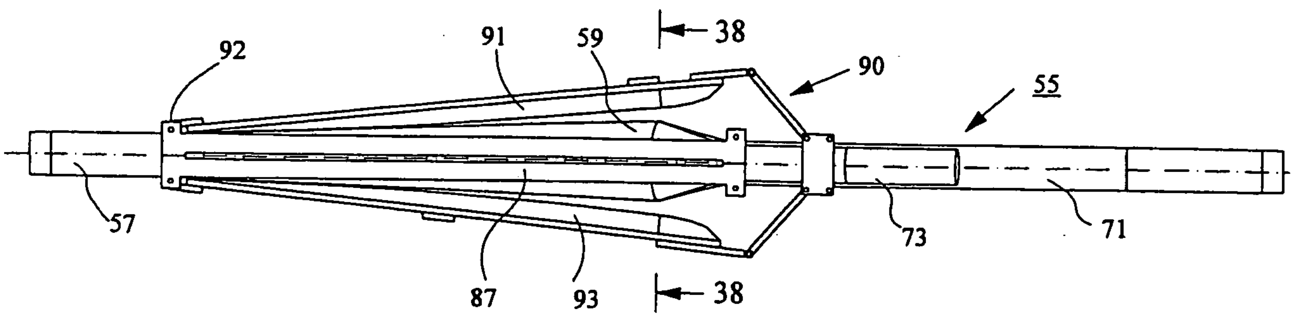


Fig. 40

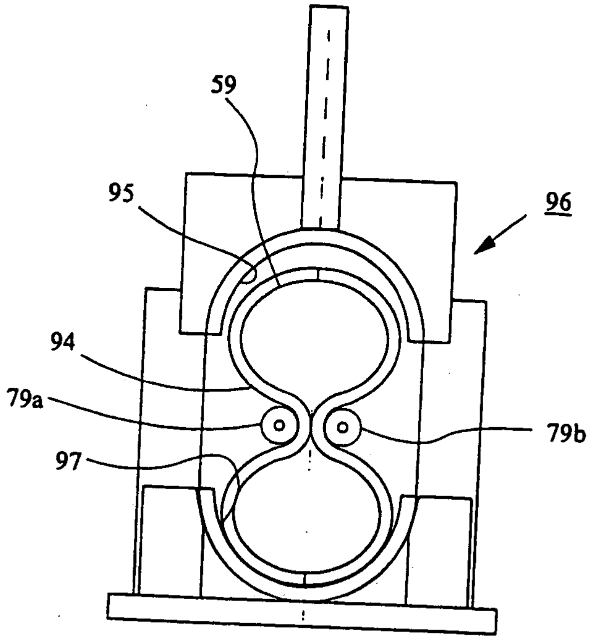


Fig. 41

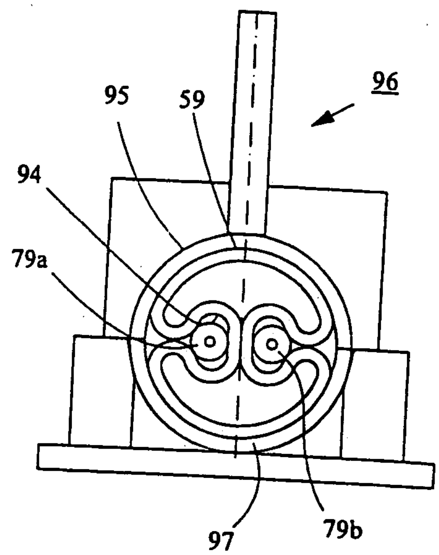


Fig. 42

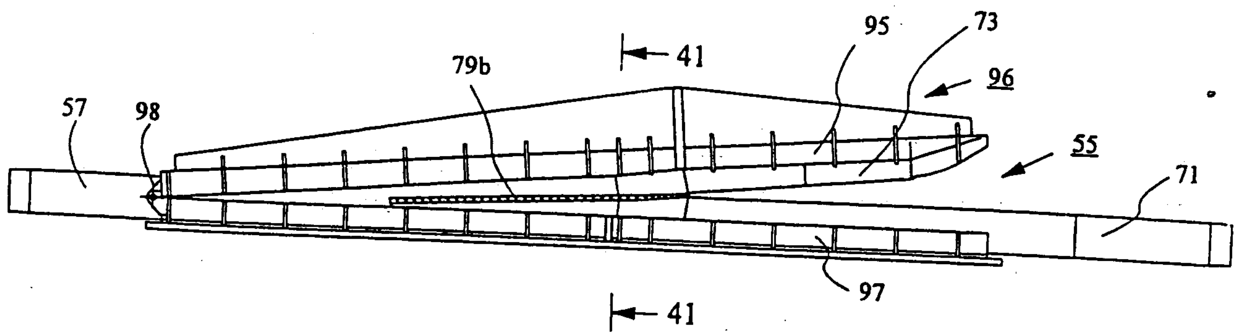


Fig. 43

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 98/01394

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B33/10 E21B43/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 06345 A (SALTEL JEAN LOUIS ;DRILLFLEX (FR); LEIGHTON JAMES (FR)) 20 February 1997 see the whole document ---	1,12
A	WO 96 23953 A (ELF AQUITAINE ;BUYTAERT JEAN (GB); WESSEL ROLAND (GB); INTEGRATED) 8 August 1996 see the whole document ---	1,12
A	US 5 388 648 A (JORDAN JR HENRY J) 14 February 1995 see column 6, line 51 - column 8, line 2 see figures 1,2 ---	1,12
A	US 2 397 070 A (J.A. ZUBLIN) 19 March 1946 see the whole document -----	1,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 1998	04/12/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schouten, A

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 98/01394

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9706345 A	20-02-1997	FR 2737534 A	07-02-1997
		AU 6744096 A	05-03-1997
		EP 0842347 A	20-05-1998
		NO 980429 A	03-04-1998
WO 9623953 A	08-08-1996	CA 2210852 A	08-08-1996
		EP 0807201 A	19-11-1997
		NO 973519 A	03-10-1997
US 5388648 A	14-02-1995	CA 2133240 A	09-04-1995
		GB 2282835 A	19-04-1995
US 2397070 A	19-03-1946	NONE	